

WHAT IS CLAIMED IS:

1
2 1. A method for restoring audio information embodied within an analog,
3 optically-recorded variable density soundtrack of a film, comprising the steps of:
4 optically scanning the soundtrack to yield a digital signal representation of the
5 audio information;
6 storing the digital signal;
7 applying at least one statistical processing technique to the stored digital signal
8 to restore at least one characteristic of the audio information.

1 2. The method according to claim 1 wherein the optically scanning step
2 further comprises the step of scanning successive lines of the soundtrack.

1 3. The method according to claim 2 wherein the step of applying the at
2 least one statistical processing technique further includes performing at least one of
3 the following operations:

- 4 (a) averaging pixel intensities over each scanned line;
5 b) calculating a standard deviation of each pixel in each line scan, eliminating
6 pixel values that deviate above a user defined threshold, and calculating mean to
7 obtain a noise reduced instantaneous amplitude;
8 c) creating a look-up-table to correct for data values derived from non-linear
9 areas of film density transfer characteristic;
10 d) performing statistical and regression analysis of the pixel intensities values
11 to extend beyond non-linear areas of film density transfer characteristic; and
12 e) performing adaptive filtering to minimize effects of inter-modulation
13 distortion.

1 4. The method according to claim 3 further comprising the step of
2 performing one the operations in response to operator selection of said one operation.

1 5. The method according to claim 3 further including the step of performing
2 a plurality of operations.

1 6. The method according to claim 3 further including the step of performing
2 all of the operations.

1 7. The method according to claim 1 further including the step of quantizing
2 the digital signal to at least 12-bit resolution.

1 8. The method according to claim 2 further including the step of
2 synchronizing the scanning of successive lines to movement of the soundtrack to yield
3 a prescribed number of line scans per unit of time.

1 9. The method according to claim 2 wherein the step of scanning
2 successive lines of the soundtrack further comprises the step of displacing the film
3 relative to a line scan camera.

1 10. The method according to claim 9 further including the step of aligning
2 the line scan camera with respect to the soundtrack so that the soundtrack
3 substantially fills a width of the line scan camera.

1 11. The method according to claim 9 further including the step of azimuth
2 aligning the line scan camera so that equal density values of the soundtrack, when
3 displayed concurrently, appear with substantially equal brightness.

1 12. The method according to claim 9 further including the step of aligning
2 the soundtrack relative to the line scan camera so that any positional variation of an
3 audio representative envelope of the soundtrack remains within a digital image of the
4 soundtrack.

1 13. The method according to claim 3 wherein the step of creating a look-up
2 table further includes the step of mapping a linear density value to a mean amplitude
3 value if the mean value falls in a linear range.

14. The method according to claim 3 wherein the step of performing adaptive filtering includes choosing an empirical filter value A_{ik} in accordance with the formula:

$$A_{ik} = (\sum \beta A_{k-1} \sin(\omega t_k + \phi) + \beta A_{k-2} \sin(\omega t_k + \phi) + \beta A_{k-3} \sin(\omega t_k + \phi) + \dots + \beta A_{k-n} \sin(\omega t_k + \phi)) + (\sum \kappa A_{k+1} \sin(\omega t_k + \phi) + \kappa A_{k+2} \sin(\omega t_k + \phi) + \kappa A_{k+3} \sin(\omega t_k + \phi) + \dots + \kappa A_{k+n} \sin(\omega t_k + \phi))$$

15. A system for restoring audio information embodied within an analog optically recorded variable density soundtrack of a film, comprising the steps of:

- a optical scanner for scanning the soundtrack to yield a digital signal representation of the audio information;
- a storage system for storing the digital signal;
- a processor for applying at least one statistical processing technique to the stored digital signal to restore at least one characteristic of the audio information.

16. The system according to claim 15 wherein the optical scanner comprises a line scan camera for scanning successive lines of the soundtrack.

17. The system according to claim 15 wherein the processor performs at least one of the following statistical processing operations:

- (a) averaging pixel intensities over each scanned line;
- b) calculating a standard deviation in each line of scanned data to eliminate extraneous pixel values.
- c) calculating the standard deviation of each pixel in each line scan, eliminating pixel values that deviate above a user defined threshold, and calculating mean to obtain a noise reduced instantaneous amplitude;
- d) creating a look-up-table to correct for data values derived from non-linear areas of film density transfer characteristic;
- e) performing statistical and regression analysis of the pixel intensities values to extend beyond non-linear areas of film density transfer characteristic; and
- f) performing adaptive filtering to minimize effects of inter-modulation distortion.

1 18. The system according to claim 17 wherein the processor performs one of
2 the statistical processing operations in response of operator selection of said one
3 operation.

1 19. The system according to claim 17 wherein the processor performs a
2 plurality of statistical processing operations.

1 20. The system according to claim 17 wherein the processor performs all of
2 the statistical processing operations

1 21. The system according to claim 16 wherein the line scan camera yields a
2 quantized digital signal having at least 12-bit resolution.

1 22. The system according to claim 16 further including means for
2 synchronizing the scanning of successive lines of the soundtrack by the camera to
3 movement of the soundtrack to yield a prescribed number of line scans per unit of
4 time.

1 23. The system according to claim 16 further including means for displacing
2 the film relative to the line scan camera.

1 24. The system according to claim 16 further including means for aligning
2 the line scan camera with respect to the sound rack so that the soundtrack
3 substantially fills a width of the line scan camera.

1 25. The system according to claim 16 further including means for azimuth
2 aligning the line scan camera so that equal density values of the soundtrack, when
3 displayed concurrently, appear with substantially equal brightness.

1 26. The system according to claim 16 further including means for aligning
2 the soundtrack relative to the line scan camera so that any positional variation of
3 an audio representative envelope of the soundtrack remains within a digital image
4 of the soundtrack.